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Association of Chronic Toxoplasmosis with Obesity and Metabolic Syndrome in Saudi Women

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Abstract **Background:** The possible relationship between chronic *Toxoplasma gondii* infection and metabolic disturbances, including obesity and metabolic syndrome (MS), remains unclear. This study assessed the prevalence of chronic toxoplasmosis, obesity, and MS among women in Saudi Arabia and examined their statistical associations. **Methods:** A cross-sectional study was conducted among 275 women attending outpatient clinics in Makkah. Data were collected through structured questionnaires, anthropometric and clinical measurements, and ELISA-based detection of *T. gondii* IgG. Obesity and MS were classified using established diagnostic criteria. Statistical analysis was performed using SPSS. **Results:** Chronic toxoplasmosis was identified in 24.7% of participants, obesity in 78.9%, and MS in 14.9%. Chronic toxoplasmosis showed no significant association with obesity ($p = 0.118$) or MS ($p = 0.465$). Obesity showed a significant association with MS ($p = 0.048$), and more than 90% of women with MS were also classified as obese. Age demonstrated significant associations with both obesity ($p = 0.014$) and MS ($p = 0.007$). MS was also associated with education level ($p = 0.0001$) and years of marriage ($p = 0.007$). No sociodemographic or reproductive factors showed significant associations with chronic toxoplasmosis (all $p > 0.05$). **Conclusion:** Obesity and metabolic syndrome were common and strongly linked in this population, whereas chronic toxoplasmosis showed no measurable association with either condition. Metabolic risk appeared to be influenced primarily by age and sociodemographic factors rather than parasitic infection. Further longitudinal and mechanistic studies are recommended to explore these pathways in greater depth.

Key Words Chronic Toxoplasmosis, Obesity, Metabolic Syndrome, Women, Saudi Arabia

INTRODUCTION

Chronic toxoplasmosis is a long-standing infection caused by *Toxoplasma gondii*, a globally distributed parasite that can affect individuals of all ages and health backgrounds. Diagnosis typically relies on serological detection of specific antibodies, which indicate prior or ongoing infection [1-4]. Although toxoplasmosis is best known for its neurological manifestations in immunocompromised individuals and its clinical importance in pregnancy [1,2,5], interest has grown in its potential influence on broader physiological systems.

Obesity, meanwhile, is a multifactorial condition shaped by genetic, environmental, and behavioral factors, including excessive caloric intake, sedentary lifestyle, and hormonal dysregulation [6,7]. Its rising global prevalence poses major public health challenges due to its association with cardiovascular disease, type 2 diabetes, and certain cancers. Limited evidence from experimental studies suggests that *T. gondii* infection may influence appetite regulation and metabolic processes, yet human findings remain inconsistent and inconclusive [8].

Metabolic syndrome (MS) is a cluster of metabolic abnormalities, including central obesity, hypertension, hyperglycemia, hypertriglyceridemia, and low high-density lipoprotein (HDL) cholesterol, that collectively increase the risk of cardiovascular disease, stroke, and type 2 diabetes [9-13]. Its development is driven by an interplay of genetic predisposition, insulin resistance, lifestyle patterns, and environmental influences [10-12]. Given the high burden of obesity and metabolic disorders in many Middle Eastern populations, including Saudi Arabia, understanding factors that contribute to or modify these conditions is of growing importance.

Recent studies have explored whether chronic *T. gondii* infection may contribute to metabolic alterations through mechanisms such as chronic low-grade inflammation, heightened insulin resistance, and disruption of lipid metabolism

[14-16]. However, the available evidence remains limited, and findings vary considerably across settings and populations.

In light of these uncertainties, and considering the cultural, dietary, and lifestyle characteristics unique to Saudi women, the present study was designed to investigate the association between chronic toxoplasmosis, obesity, and metabolic syndrome among women in Makkah. The goal was to clarify whether chronic *T. gondii* infection plays a measurable role in metabolic health within this population.

METHODS

Study Area

This study was conducted in Makkah, located in the western region of Saudi Arabia. Previous research in the area has documented the occurrence of chronic toxoplasmosis, providing relevant context for exploring its potential metabolic associations in this population.

Study Design

A cross-sectional study was undertaken to examine whether chronic *Toxoplasma gondii* infection is associated with obesity or metabolic syndrome among adult women. The study design allowed for simultaneous assessment of exposure and metabolic outcomes within the same population.

Population and Sampling

The study included women aged 18 to 55 years attending outpatient clinics at the Maternal and Child Hospital in Makkah. A convenience sampling method was used due to the clinical setting and availability of participants. Women with pregnancy, acute illness, or diagnosed immunodeficiency were excluded to minimize confounding. A total of 275 women were enrolled based on feasibility and alignment with previous epidemiological research.

Ethical Approval

Ethical approval was obtained from the Research Ethics Committee of the Maternal and Child Hospital (approval number: insert when available). All procedures followed institutional and national ethical guidelines. Written informed consent was obtained directly from each participant, and all data were anonymized to ensure confidentiality.

Data Collection

Data were collected through a structured, interviewer-administered questionnaire that captured demographic, reproductive, and lifestyle information. Anthropometric and clinical measurements included height, weight, body mass index, blood pressure, and random blood glucose levels. All measurements were performed by trained healthcare personnel using standardized procedures.

Blood Sample Collection

A venous blood sample of approximately 5 mL was drawn aseptically from each participant. Samples were centrifuged to separate serum, which was transferred to labeled cryovials and stored at −20°C until analysis.

Assessment of Obesity and Metabolic Syndrome

Obesity was classified using body mass index (kg/m²) according to standard WHO definitions. Metabolic syndrome was diagnosed when three or more of the following criteria were present: waist circumference ≥88 cm, blood pressure ≥130/85 mmHg or antihypertensive treatment, fasting glucose ≥100 mg/dL, triglycerides ≥150 mg/dL, or high-density lipoprotein cholesterol <50 mg/dL.

Laboratory Analysis

Chronic *T. gondii* infection was determined using an ELISA IgG kit (Human-Toxo®) following the manufacturer's instructions. The assay detects specific IgG antibodies indicative of previous or chronic infection. Quality control procedures recommended by the manufacturer were followed throughout the testing process.

Statistical Analysis

Data analysis was performed using SPSS version 26 (licensed). Descriptive statistics were used to summarize participant characteristics. The Shapiro-Wilk test was applied to assess normality of continuous variables. Associations between categorical variables were examined using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Prevalence of Toxoplasmosis

The results obtained in the current study were detected using ELISA IgM and IgG for acute and chronic toxoplasmosis respectively. From 275 samples from women who participated in the study about 4/275 were positive to IgM (1.5%) and 68/275 were positive to IgG (24.7%).

Prevalence of Obesity

According to the definition of obesity, the results showed 58/275 (21.1%) were normal and 217/275 (78.9%) were abnormal. From abnormal results, about 1 (0.4%) was underweight, 99 (36.0%) were obesity grade 1, 106 (38.5%) were obesity grade 2, and 11 (4.0%) were obesity grade 3 as shown in Figure 1.

Prevalence of Metabolic Syndrome

The results found in the current study showed that the prevalence of metabolic syndrome was 41 (14.9%). The prevalence of MS increased with age; women aged between 28 and 45 years were more susceptible to MS.

The Relationship between Chronic Toxoplasmosis, Obesity, and MS

The relationship between chronic toxoplasmosis and obesity wasn't detected in the current study ($p<0.05$), also the association between chronic toxoplasmosis and MS wasn't found ($p<0.05$) (Table 1). The relationship between obesity

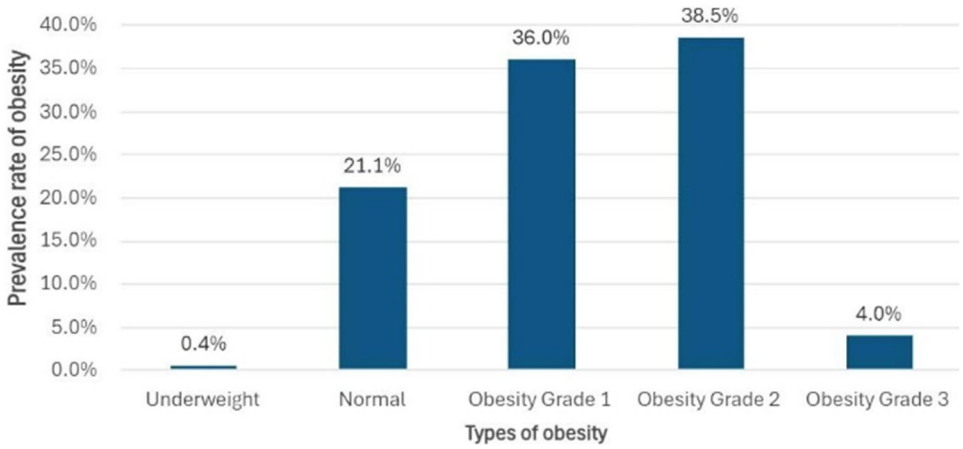

Figure 1: The Spread of Obesity among women in Saudi Arabia

Table 1: The Relationship between Chronic Toxoplasmosis and Obesity and Metabolic Syndrome (MS)

Variable	Toxo Positive	Toxo Negative	Total	X^2	P-value
Obesity					
Yes	58(26.9%)	158(73.1%)	216	2.442	0.118
No	10(16.9%)	49(83.1%)	59		
Metabolic Syndrome					
Yes	12 (29.3%)	29 (70.7%)	41	0.534	0.465
No	56 (23.9 %)	178 (76.1%)	234		

Table 2: The Relationship between Metabolic Syndrome (MS) and Obesity

Variable	MS-Yes	MS-No	Total	X^2	P-value
Obesity					
Yes	37(17.1%)	179(82.9%)	216	3.913	0.048
No	4(6.8%)	55 (93.2%)	59		

Table 3: Risk Factors Associated with Toxoplasmosis

Variable	Toxo-Positive	Toxo-Negative	Total	X^2	P-value
Age (Years)					
18-27	20(20.4%)	78(79.6%)	98	1.526	0.217
28-45	48(27.1%)	35(72.9%)	177		
Education					
Educated	65(25.0%)	195(75.0%)	260	3.176	0.529
Uneducated	3(20.0 %)	12(80.0 %)	15		
Occupation					
Housewife	58(26.0%)	165(74.0%)	223	5.229	0.073
Employee	10 (27%)	27(73.0%)	37		
Student	0(0.0 %)	15(100%)	15		
Abortion					
Yes	23(21.9%)	82(78.1%)	105	0.727	0.394
No	45(26.5%)	125(73.5%)	170		
Years of Married					
<1	6(15%)	34(85%)	40	3.709	0.157

and MS was found in the present study (p>0.05) (Table 2). More than 90% of MS were the same cases suffering from obesity (p>0.0001) using the McNemar test.

The Risk Factors associated with Toxoplasmosis Infection

The risk factors studied in the study showed no association between them and acquired infection with chronic toxoplasmosis as shown in Table 3, all the p-values detected were more than 0.05.

Table 4: Risk Factors Associated with Obesity

Variable	Obese-Positive	Obese-Negative	Total	X^2	P-value
Age (Years)					
18-27	69(70.4%)	29(29.6%)	98	5.983	0.014
28-45	147(83.1%)	30(16.9%)	177		
Education					
Educated	202 (77.7%)	58 (22.3%)	260	2.059	0.151
Uneducated	14 (93.3 %)	1 (6.7 %)	15		
Occupation					
Housewife	174(78.0%)	49(22.0%)	223	5.584	0.061
Employee	33(89.2%)	4(10.8%)	37		
Student	60(0.0 %)	40(100%)	15		
Abortion					
Yes	84(21.9%)	21(78.1%)	105	0.213	0.644
No	132(26.5%)	38(73.5%)	170		
Years of Married					
<1	30(15%)	10(85%)	40	4.221	0.121
1-5	59(22%)	23(78%)	82		
>5	127(28.8%)	26(71.2%)	153		

The Risk Factors associated with the Obesity

The main result in this section showed a significant between obesity and age, the result detected that obesity increased with age (p>0.05) as shown in Table 4.

The Risk Factors associated with MS

In this study, the relationship between acquired metabolic syndrome and age was detected (p>0.05), aged women can acquire MS compared with younger women. There was high significance between MS and education (p>0.05), educated women can acquire MS more than uneducated women. Women who got married more than 5 years acquired MS more than women who got married recently (p>O.OS) (Table 5).

DISCUSSION

This study examined the relationships among chronic toxoplasmosis, obesity, and metabolic syndrome in a sample of women in Makkah. The findings demonstrated a strong association between obesity and metabolic syndrome, while no significant relationship was detected between chronic

Table 5 Risk Factors Associated with Metabolic Syndrome (MS)

Variable	MS-Positive	MS-Negative	Total	X^2	P-value
Age (Years)					
18-27	7(7.1%)	91(92.9%)	98	7.239	0.007
28-45	34(19.2%)	143(80.8%)	177		
Education					
Educated	34 (13.1%)	226 (86.9%)	260	12.613	0.0001
Uneducated	7 (46.7 %)	8 (53.73%)	15		
Occupation					
Housewife	35(15.7%)	188(84.3%)	223	2.787	0.248
Employee	6(16.2%)	31(83.8%)	37		
Student	0(0.0 %)	15(100%)	15		
Abortion					
Yes	19(18.1%)	86(81.9%)	105	1.359	0.244
No	22(12.9%)	148(87.1%)	170		
Years of Married					
<1	3(7.5%)	37(92.5%)	40	9.807	0.007
1-5	6(7.3%)	76(92.7%)	82		
>5	32(20.9%)	121(79.1%)	153		

Toxoplasma gondii infection and either metabolic outcome. These results contribute to the growing body of evidence exploring metabolic health risks among women in Saudi Arabia.

Obesity remains a major global and regional public health challenge and is associated with increased risks of cardiovascular disease, type 2 diabetes, and certain cancers [17]. Its rising prevalence, including in Saudi Arabia, has placed additional burdens on healthcare systems and underscores the importance of identifying relevant biological and sociodemographic factors [18]. Metabolic syndrome, characterized by central obesity, insulin resistance, dyslipidemia, and hypertension, similarly increases the likelihood of cardiovascular and metabolic diseases [19]. Its development is influenced by genetic predisposition, diet, lifestyle, and environmental exposures [20]. Chronic toxoplasmosis, in contrast, is typically asymptomatic but can persist for years and has been linked to neurological and systemic complications, particularly in immunocompromised individuals [21].

Although previous studies have suggested potential associations between chronic toxoplasmosis and metabolic abnormalities [8,22,23], the current findings did not support such relationships. Biological pathways proposed in the literature include chronic low-grade inflammation, increased insulin resistance, alterations in lipid metabolism, and parasite-induced changes in appetite regulation [22,24-26]. While these mechanisms are plausible, their clinical relevance in humans remains inconsistent and may vary across populations. The absence of significant associations in this study suggests that chronic toxoplasmosis may not exert measurable metabolic effects in this cohort of Saudi women.

In contrast, the strong association identified between obesity and metabolic syndrome aligns with established evidence demonstrating that excess adiposity plays a central role in the development of metabolic disturbances. Insulin resistance, dysregulated lipid metabolism, and adipose tissue inflammation are widely recognized contributors to the pathophysiology of metabolic syndrome [19,20]. The observed influence of age, education, and marital duration on metabolic syndrome further reflects known demographic patterns in the region, where sociocultural factors shape lifestyle behaviors and long-term metabolic risk.

These findings hold public health relevance for Saudi Arabia, where obesity and metabolic disorders are increasingly prevalent among women. Targeted interventions focusing on lifestyle modification, early metabolic screening, and public health education may therefore yield substantial benefits. Although chronic toxoplasmosis did not appear to contribute to metabolic outcomes in this study, further research, particularly longitudinal studies and investigations incorporating dietary and socioeconomic factors, would help clarify whether subtle or population-specific interactions exist.

CONCLUSIONS

This study provides important insights into the metabolic health of women in Makkah by examining the relationship between chronic toxoplasmosis, obesity, and metabolic syndrome. While obesity and metabolic syndrome were found to be strongly associated, no significant link was identified between chronic toxoplasmosis and either condition. These findings suggest that metabolic risk in this population is driven primarily by demographic and lifestyle factors rather than chronic *T. gondii* infection. Future research should employ longitudinal designs and incorporate broader metabolic, behavioral, and immunological assessments to clarify potential biological interactions and better inform targeted public health interventions.

Strengths and Limitations

This study has several strengths, including the use of laboratory-confirmed ELISA IgG testing for accurate identification of chronic *Toxoplasma gondii* infection, standardized clinical measurements, and a sample of 275 women that provides adequate power for detecting major associations. However, the findings should be interpreted with caution due to important limitations. The cross-sectional design prevents causal inference, and the absence of longitudinal follow-up limits understanding of temporal relationships between infection and metabolic outcomes. Potential confounders such as dietary habits, physical activity, and socioeconomic status were not assessed, which may have influenced the results. Additionally, convenience sampling from a single hospital setting may introduce selection bias and restrict the generalizability of the findings to the broader population of Saudi women.

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